Neap:

Trial Examination 2013

VCE Physics Unit 2

Written Examination

Suggested Solutions

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Area of study 1 – Motion

Question 1 (17 marks)

a. $s = 0.5 \times a \times t^2$

$= 5 \times 2.5^2$ 1 mark

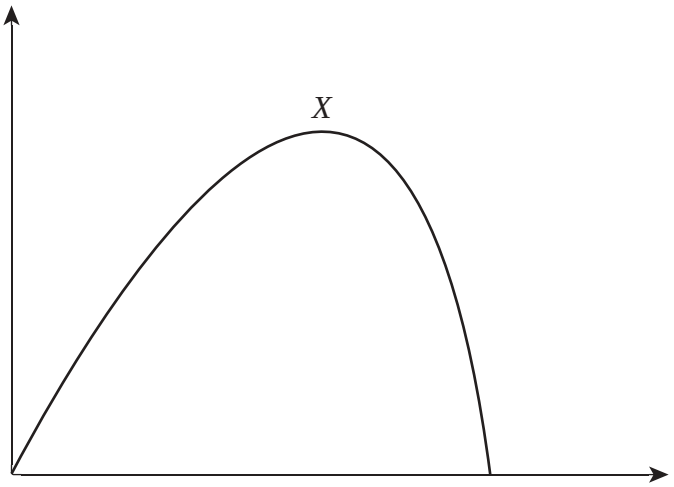
s = 31 1 mark

b. $v = a \times t$

$= 10 \times 2.5$ 1 mark

$= 25 \text{ m s}^{-1}$ 1 mark

c.



Straight-line (constant acceleration) section 1 mark
Continue to increase velocity when acceleration decreases. 1 mark
X at highest point 1 mark

d. $m = \frac{F}{g}$

$= \frac{650 \text{ N}}{10}$

$= 65 \text{ kg}$ 1 mark

e. $E_{\text{gravitational}} = E_{\text{elastic}}$ 1 mark

$mgh = E_{\text{elastic}}$

$65 \times 10 \times 60 = 39\ 000 \text{ J}$ 1 mark

f. $E = 0.5kx^2$

$x = 60 - 31 = 29 \text{ m}$ (consequential of part **a.**) 1 mark

$k = \frac{2 \times E}{x^2}$

$= \frac{78\ 000}{841}$ 1 mark

$= 93 \text{ N m}^{-1}$ (or 95 N m^{-1} if using $s = 31.3$ m) 1 mark

g. weight (down) and tension (up) 1 mark
Tension is greater than weight. 1 mark

h. **i.** Velocity is zero. 1 mark

ii. Acceleration is up because the net force is up. 1 mark

Question 2 (11 marks)

a. $v = \frac{s}{t}$

$= \frac{39\ 000\ \text{m}}{630\ \text{s}}$ 1 mark

$= 62\ \text{m s}^{-1}$ 1 mark

b. When the air resistance reaches a value that is equal (but opposite) to the weight, the net force is zero. 1 mark

Because the net force is zero, there is no acceleration and the velocity remains constant. This is known as terminal velocity. 1 mark

c. $a = \frac{\Delta v}{t}$

$= \frac{\left(\frac{1170}{3.6}\right)}{225\ \text{s}}$ 1 mark

$= 1.44\ \text{m s}^{-2}$ 1 mark

d. At the very start when Felix's downward velocity was still zero, his downward acceleration would have been 'g'. 1 mark

As soon as he increased his velocity, air resistance would have reduced the value for acceleration. 1 mark

e. work = Δ kinetic energy + Δ potential energy 1 mark

$F \times s = 0.5mv^2 + mgh$

$F = \frac{(0.5 \times 65 \times 325^2) + (65 \times 10 \times 2500)}{39\ 000 - 36\ 500}$ 1 mark

$= 2023\ \text{N}$ 1 mark

Question 3 (10 marks)

a. $p = m \times v$

$= 0.06\ \text{kg} \times 73\ \text{m s}^{-1}$ 1 mark

$= 4.4\ \text{kg m s}^{-1}$ 1 mark

b. $\text{Power} = \frac{\Delta E_{\text{kin}}}{t}$ 1 mark

$= \frac{0.5 \times 0.06 \times 73^2}{0.15}$

$= 1065\ \text{W}$

$= 1.1 \times 10^3\ \text{W}$ 1 mark

c. Δp = impulse

$\Delta p = 2p_{\text{original}}$ 1 mark

$\Delta p = 2 \times 4.4$ kg m s^{-1} (consequential of part **b.**)

$= 8.8$ kg m s 1 mark

d. Even though the momentum of the tennis ball changes, the momentum of the Earth changes by an equal and opposite amount. 1 mark

Since the Earth is massive, the small change in v is not measurable. 1 mark

e. The ball exerts a force on the wall. The reaction to this force is the wall pushing against the ball. 1 mark

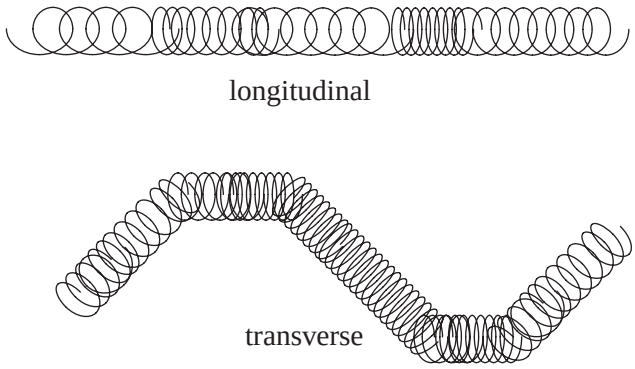
This force causes the ball to deform and flatten. 1 mark

Area of study 2 – Wave-like properties of light

Question 1 (1 mark)

B. Waves transfer energy without transferring matter. 1 mark

Question 2 (3 marks)



1 mark

There are two types of waves, longitudinal and transverse: 1 mark

- Longitudinal has the movement of the wave parallel to the direction of wave travel
- Transverse has the movement of the wave perpendicular to the direction of wave travel

1 mark

Question 3 (7 marks)

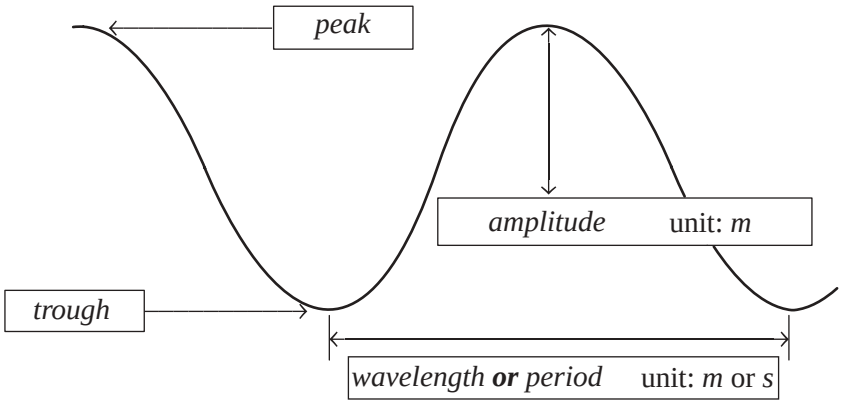
a. There are five waves in 10 cm, so the wavelength is $\frac{10}{5} = 2$ cm. 1 mark

b. The time taken for five waves = 0.5 s, so for one wave $T = \frac{0.5}{5} = 0.1$ s 1 mark

Now $f = \frac{1}{T} = \frac{1}{0.1} = 10$ Hz 1 mark

c. Use $v = \lambda f = 2 \times 10 = 20$ cm s^{-1} (consequential of parts **a.** and **b.**) 1 mark

d.



3 marks

Award half a mark for each correct word and unit.

Question 4 (6 marks)

a. The white ray has undergone refraction. 1 mark

The amount of refraction (dispersion) is dependent on the wavelength (colour) of light. 1 mark

b. In this case the light rays have undergone **total internal reflection** after the dotted lines. 1 mark

This can only happen if the angles with which the dotted lines strike the water–air boundary are above the critical angle for each colour. 1 mark

c. Using Snell's Law, $1 \times \sin(27°) = 1.331 \sin R_2 \rightarrow R_2 = 19.9°$ 2 marks

Question 5 (3 marks)

- critical angle for naked fibre: $\theta_c = \sin^{-1}\left(\frac{1}{1.46}\right) = 43.2°$ 1 mark
- critical angle for cladded fibre: $\theta_c = \sin^{-1}\left(\frac{1.44}{1.46}\right) = 80.5°$ 1 mark
- increase in critical angle = $80.5 - 43.2 = 37.3°$ 1 mark

Question 6 (2 marks)

	Particle model	**Wave model**
Reflection	✓	✓
Refraction	×	✓

2 marks

Award half a mark for each correct box.

Question 7 (2 marks)

C. The frequency of blue light (Blu-ray) is shorter then red (DVD) and both travel at the same speed.

2 marks

Question 8 (4 marks)

a. The blue paper absorbs all the colours 1 mark
and reflects only the blue light, so the paper appears blue. 1 mark

b. Since the filter allows (mostly) blue light through, 1 mark
when Matt and Hannah look at the paper it will still appear blue as the paper will reflect
the blue (filtered) light. Therefore, Hannah is correct. 1 mark

DETAILED STUDIES (2 marks for each correct answer)

Detailed study 1 – Astronomy

Question 1 D

Constellations are patterns of stars only visible from our perspective. In reality, these stars could be varying distances from Earth.

Question 2 B

Because of the Earth's rotation around the Sun, the sidereal day is 4 minutes shorter than 24 hours. The 24-hour day is defined with our position relative to the Sun.

Question 3 B

If you have the South Celestial Pole in the Zenith, all stars would make diurnal motions parallel to the horizon.

Question 4 C

The CSP is observed 38° above the Southern horizon.

Question 5 C

Only the phases of Mercury and Venus are unable to be explained in a Ptolomeic system, as the phases result from their rotation around the Sun.

Question 6 B

As the period of orbital rotation of the Moon is equal to the rotation around its own axis, the Moon always shows the same 'face' towards the Earth. This is not a coincidence, but a result of billions of years of gravitational interaction between the Moon and the Earth.

Question 7 C

A nebula is a volume of space filled with cool dust and gas that can obscure the starlight from behind it. Some nebulae are lit from within by young stars formed within the nebula.

Question 8 A

This is a refracting telescope. Galilean telescopes use a concave lens for the eyepiece. Newtonian and reflecting telescopes use mirrors for their objectives.

Question 9 B

$$\frac{75 \text{ mm}}{15} = 5 \text{ mm}$$

Question 10 D

A greater diameter of the objective will allow more light to enter the telescope. This means more information and hence more detail.

Question 11 D

Data collection in modern telescopes use CCDs and computers to record images and data.

Question 12 D

The Earth's atmosphere is mostly opaque in the part of the spectrum from 10 m and beyond.

Detailed study 2 – Astrophysics

Question 1 C

The relationship is $\frac{1}{r^2}$ and Graph C best approximates this.

Question 2 A

The total power output remains more or less constant; it just gets spread over a larger area as the distance increases.

Question 3 D

The relationship is quartic and this is best given by Graph D.

Question 4 B

The parsec is defined using this right-angled triangle.

Question 5 D

1 AU is equal to the 150 million kilometres of Earth's radius, so using trigonometry:

$$\tan(0.5°) = \frac{1}{\text{adjacent (a)}} \rightarrow a = \tan(0.5°) = 115 \text{ AU}$$

Question 6 A

The mass of Jupiter is not sufficient to enable gravity to start the required nuclear reactions.

Question 7 C

Fusion is the principal reaction in a star.

Question 8 D

The other sequences are incorrect.

Question 9 A

The change in frequency for a wave is known as the Doppler effect.

Question 10 B

The visible light would move towards the blue end of the visible spectrum.

Question 11 D

Spiral galaxies have a minimum of two arms and elliptical galaxies have older-type stars.

Question 12 A

It is thought that slight density variations in the mass allowed matter to clump together to eventually form galaxies.

Detailed study 3 – Energy from the nucleus

Question 1 B

The nucleus is held together by the strong nuclear force and electrons are held to the nucleus by the electrostatic force of attraction.

Question 2 A

The binding energy is a measure of the energy required to pull nucleons apart.

Question 3 C

Fusion of light elements make the atom more stable; heavier elements are more unstable and fission into smaller elements increases their stability.

Question 4 A

The energy produced per day is $3.9 \times 10^{26}\ \text{W} \times 3600 \times 24 = 3.37 \times 10^{31}\ \text{J}$, and using $E = mc^2$,

$$m = \frac{3.37 \times 10^{31}\ \text{J}}{(3.0 \times 10^{8})^2} = 3.37 \times 10^{14}\ \text{kg}.$$

Question 5 D

Convert eV to J.

$1.44 \times 10^{6} \times 1.6 \times 10^{-19} = 2.3 \times 10^{-13}\ \text{J}$.

Then divide total energy by energy per reaction:

$$\frac{3.9 \times 10^{26}}{2.3 \times 10^{-13}} = 1.7 \times 10^{39}\ \text{reactions}$$

Question 6 D

U-235 requires slow-moving neutrons while Pu-239 can capture fast-moving neutrons.

Question 7 B

Component *S* is the heat exchanger.

Question 8 C

Component *Q* are the control rods, and their main function is to slow down the reaction.

Question 9 D

Component *T* is the containment structure.

Question 10 A

U-235 and Pu-239 are most commonly used in nuclear reactors.

Question 11 D

X is a neutron, and three neutrons are needed to complete the equation. Energy is also released.

Question 12 B

Current technology cannot sustain the fusion process.

Detailed study 4 – Investigations: Flight

Question 1 C

Drag and thrust require a forward velocity and engine power. Neither are present in the balloon.

Question 2 D

Weight and drag are not usually described as reaction forces. Thrust in a jet engine is a reaction to the forceful emission of gases from the engine, and lift can be explained as the reaction to the downward force on the air by the wing.

Question 3 B

Conservation of momentum provides an alternative, or complimentary, explanation for lift: the wing causes a downward impulse on the air as it moves. This is matched by an equal and opposite change impulse on the wing/aircraft, thus creating lift.

Question 4 D

According to Bernoulli's principle, the pressure in a fluid is proportional to the velocity of the fluid.

Question 5 C

Since L is proportional to v^2, lift will increase fourfold.

Question 6 A

According to Bernoulli's principle, the faster air at the end of tube B will result in localised low pressure, and so the higher normal pressure will push the ink up into tube B.

Question 7 B

$$\begin{aligned}\text{weight} &= m \times g \\ &= 400 \times 10^3 \text{ kg} \times 10 \\ &= 4 \times 10^6 \text{ N}\end{aligned}$$

and to achieve take-off a force greater than weight is required.

Question 8 C

The lower air densities at higher altitude reduce the drag and therefore less power is required to maintain airspeed.

Question 9 **C**

$P = F \times v$

$140 \text{ MW} = F \times 250 \text{ m s}^{-1}$

$F = 560 \text{ kN}$

Question 10 **C**

The graph shows a straight line with a positive gradient for values below 10°, but not going through the origin of the graph.

Question 11 **C**

Stall is defined as the angle of attack at which the value for lift begins to decline.

Question 12 **D**

The increased drag would cause a reduced lift on the left-hand side of the plane, hence it would rotate anti-clockwise. In addition to this, the same drag increase would result in a reduction of torque on the left wing, causing the plane to turn left.

Detailed study 5 – Investigations: Sustainable energy sources

Question 1 **B**

Nuclear energy is not renewable because uranium is a finite resource that cannot be replenished.

Question 2 **C**

maximum power at $V = 0.375$ V and $I = 1.6$ A

$P = V \times I = 0.6$ W

Question 3 **A**

$$\text{efficiency} = \left(\frac{\text{output}}{\text{input}}\right) \times 100\%$$

$$= \left(\frac{(0.72 \text{ W} \times 100)}{600}\right) \times 100\%$$

$$= 12\%$$

Question 4 **B**

$250 \times 10\% = 25 \text{ W m}^{-2}$

$25 \text{ W m}^{-2} \times 10 \text{ h} = 250 \text{ W h}^{-1} = 0.25 \text{ kWh m}^{-2}$

$\frac{20}{0.25} = 80 \text{ m}^2$

Question 5 **C**

$20 \text{ kWh} \times 3600 \times 365 = 26\,280\,000 \text{ kJ per year}$

$\frac{4.32 \times 10^{10} \text{ MJ}}{26\,280 \text{ MJ}} = 1\,640\,000 \text{ homes}$

Question 6 **B**

input = $29 \text{ MJ kg}^{-1} \times 17.3 \times 10^9 \text{ kg} = 5.02 \times 10^{11} \text{ MJ}$

ouput = $4.32 \times 10^{10} \text{ MJ}$

efficiency = $\dfrac{4.32 \times 10^{10} \text{ MJ}}{5.02 \times 10^{11} \text{ MJ}} = 8.6\%$

Question 7 **C**

$\dfrac{1.6 \text{ GW}}{3 \text{ MW}}$ = about 500 turbines

Question 8 **D**

In an effort to reduce Australia's CO_2 pollution, the government wants to close the most carbon-intensive power stations.

Question 9 **B**

Variable wind speeds mean that the average power output is always lower than the maximum.

Question 10 **D**

Since P is proportional to v^3, power output will increase $2^3 = 8$ times if the wind speed doubles.

Question 11 **A**

The differential heating of the atmosphere causes high and low pressure areas which leads to air movement. This in turn rotates the wind turbine and generates electricity.

Question 12 **D**

Replacing all fossil fuels would require a mixture of many different sources of renewable energy.

Detailed study 6 – Medical physics

Question 1 **D**

X-ray has been around the longest.

Question 2 **A**

Ultrasounds typically have frequencies greater than 1 MHz.

Question 3 **C**

The frequency remains constant, and since the speed increases as it goes from fat to muscle, the wavelength must also increase.

Question 4 **B**

X-rays can damage cells and so potentially pose a risk to a foetus.

Question 5 B

Bundle A must be coherent and bundle B can be incoherent.

Question 6 B

Increasing the number of fibres (bundles) causes the image quality to improve.

Question 7 C

Laser light has a much narrower wavelength than ordinary visible light.

Question 8 A

MRIs involve emission and detection of radio waves.

Question 9 C

For the radioisotope to work effectively it needs a half-life that is at least in the hours range.

Question 10 D

Bones absorb X-rays but not gamma-rays.

Question 11 D

When a nucleus is deficient in neutrons a proton may decay into a neutron and positron.

Question 12 C

Plastic aprons are not a safety measure for dealing with X-rays.